UDC 666.3.03.4:621.74.001.6

INJECTION MOLDING PLANT FOR CERAMIC PRODUCTION

Yu. N. Kryuchkov[1] **and V. V. Lashneva**[1]

Translated from Steklo i Keramika, No. 10, pp. 19 – 20, October, 1998.

An injection molding plant for the production of long ceramic articles is described, including the functional principle and operating parameters.

Great attention is currently being paid to improvement of production of ceramic articles by the slip casting method [1, 2]. One of the most promising fields of research involves overflow and gate runner molding. An increase in the slip pressure makes it possible to significantly intensify the process and increase the density of the intermediate product, which lowers product shrinkage in drying and firing and, consequently improves the product quality. For example, in pressure casting of plates, additional compaction can be implemented by pressing the casting after injection molding (it is done either by bringing the half-molds nearer to each other to a distance of 1 – 2 mm and compressing to the same value the elastic collar installed along the perimeter of the cast article to seal the mold, or by introduction of a blow-hole-former in the cast article).

It is shown in [3] that an increase in the pressure of the slip fed into a porous mold does not always ensure high density of the casting. In casting by pouring, for example, the particles of the casting at the slip boundary virtually are not compacted (since the pressure difference is close to zero). A similar result occurs in casting of long ceramic pieces, especially articles made of slip based on clay-free mixtures due to a decrease in the casting density in the area remote from the pouring gate, since the poured ceramic mixture blocks the gate and slip stops coming into the mold.

It is difficult to implement casting of long articles by the traditional injection molding method in a mold containing dead-end channels connected with a compressed air source and a vacuum system (the method involves pressurized filling of the working space of the mold with slip, molding of the cast article in the mold, consecutive separation of the cast article from the mold parts by supplying a pulse of compressed air, and subsequent removal of the cast article from the mold) [4].

The Institute of Material Science Problems of the Ukrainian National Academy of Sciences has developed an injection casting plant for long ceramic articles, based on a press for injection molded plastics. The machine makes it possible to develop in molding a pressure gradient along the length of the working space of the mold by installing hollow torus-shaped elastic dividing elements in the mold channels. The external diameter of the dividing elements is equal to the channel diameter and they are filled with air at ambient atmospheric pressure.

The existence of the torus-shaped elements in the channels increases the route that the filtrate has to pass in the mold in the course of molding in the runner gate area. This makes it possible to develop a pressure gradient along the length of the working space of the mold, which results in a decrease in the filling rate in the pouring gate area, and thus prevents premature blocking of the gate by the ceramic mixture and ensures an increase in the homogeneity and density of the cast article.

Figure 1 shows the scheme of the injection molding plant for ceramic articles. The machine is designed as a press with a stationary plate *1* and a mobile plate *2* to which the lower *3* and the upper *4* half-molds with channels *5* are fixed. The channels are connected by valves either with the vacuum system (in molding), or with the gas main with increased air pressure (in blowing). The half-molds in the joined state form a working space *6* for product molding, which is connected through the runner gate *7* with the slip vessel *8*. There

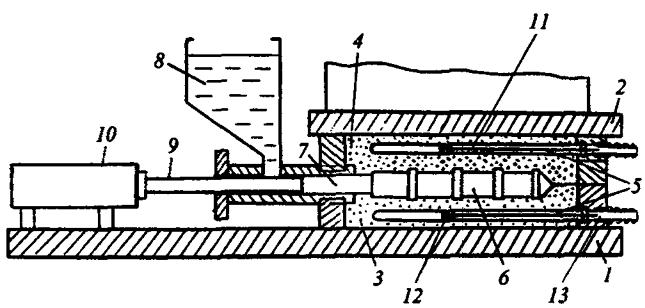

Fig 1.

[1] Institute of Material Science Problems of the Ukrainian National Academy of Sciences, Kiev, Ukraine.

0361-7610/98/0910-0317$20.00

is a rod *9* placed in the runner gate which is pushed by a hydraulic cylinder *10*. In the initial state, the rod blocks the entrance to the runner and thus acts additionally as a valve.

In the mold channels, torus-shaped hollow elastic dividing elements *12* are fixed by threaded rods *11*. The dividing elements are filled with air at ambient pressure and their external diameter is equal to the channel diameter. The position of the dividers inside the channels in molding determines the pressure gradient along the length of the articles; therefore they can be shifted by rotation using the guiding thread. The position of the dividing elements was previously determined experimentally. The mold channels are connected with the vaccuum system and the compressed air source through pipe connections *13*. The valves and cocks make it possible to connect the channels to both the vacuum and the compressor system.

In order to test the proposed method, ceramic rods about 70 mm long and 8 mm in diameter were cast from slip based on finely disperse aluminum oxide acidified with hydrochloric acid up to pH = 4.0. Casting was carried out in a porous polymer mold with two channels in which two hollow torus-shaped elastic elements were placed at a distance of 60 mm from the open end.

The process took place in the following way. The half-molds were closed employing the press. The slip vessel was filled with slip, while the pouring gate was blocked with the rod. Later both channels were connected to the vacuum system, developing rarefaction of 0.075 MPa in the working space, and the rod was retracted. In this manner, the bottom hole of the slip vessel opened and ceramic slip was sucked into the working cavity. The presence of the dividing elements in the channels made it possible to develop the highest pressure difference across the mold section in the working space area most remote from the gate, which caused faster filling of the mold in the area furthest from the gate and in this way prevented the emergence of a ceramic plug in the gate runner area. This provided for more homogeneous and denser filling of the working cavity with slip. Filling of the working space of the mold lasted for 20 sec.

After the mold was filled, the hydraulic cylinder was turned on. The cylinder pushed the retractable rod toward the casting and in this way compacted it. After that, the cylinder rod was retracted to the initial position. Later on, a pulse of compressed air at a pressure of 0.4 MPa was sent to the lower half-mold channel. At the same time, the elastic dividing element was compressed, the compressed air filled the entire channel, developing excessive pressure uniformly over the entire volume of the lower half-mold, and through the pores blew the cast article off the inner surface of the lower half-mold. After that, the upper half-mold together with the casting inside was raised to the upper position and a pulse of compressed air was sent into the upper channel. The air compressed the elastic divider of the upper half-mold and filled the entire channel, developing excessive pressure uniformly over the entire inner working surface of the upper half-mold and separating the casting from the upper half-mold to a receiving tray. After that, the casting cycle was repeated.

In the case of casting in a mold equipped with torus-shapes hollow elastic elements, the cast pieces were high-density and homogeneous. The density of the cast articles was 2.4 – 2.6 g/cm^3.

For reference, ceramic rods 8 mm in diameter and 70 mm long were cast from the same slip and with the same technological parameters as in the former case. The sequence of casting operations remained unchanged. Prior to the beginning of the process, the torus-shaped elastic elements were removed from the mold. After casting in the mold without torus-shaped elastic elements, the cast pieces had a low density and exhibited cavities due to blocking of the pouring gate with the ceramic mixture. The average density of these castings was 1.93 g/cm^3.

Thus, the presence in the channels of hollow elastic torus-shaped dividing elements filled with air at ambient pressure whose external diameter is equal to the channel diameter makes it possible to develop the highest pressure difference accross the mold section in the working space area farthest from the pouring gate, and development of a pressure gradient along the length of the working space of the mold causes a lower filling rate in the gate area, prevents the appearance of a ceramic plug in this area, and contributes to the production of more homogeneous and denser castings.

REFERENCES

1. I. Moravek, "Moglichkeiten Intensiviezerung des Jiessprozesses," *Keram. Zeitschr.*, 35(3), 130 – 134 (1985).
2. Yu. N. Kryuchkov, "Optimization of production of ceramic articles using the slip casting method," *Steklo Keram.*, No. 2, 14 – 15 (1992).
3. Yu. N. Kryuchkov, "Calculation of nonstationary pressure field in a cast article in slip casting of ceramic products," *Steklo Keram.*, No. 1, 25 – 26 (1990).
4. V. D. Boguslavskii and Yu. N. Kryuchkov, *New Types of Molds for Fine Ceramics*, Issue 1, TsNIITÉIlegprom, Moscow (1985).